

DRAFT FINAL

**HUMAN HEALTH RISK
ASSESSMENT REPORT
ELIZABETH MINE**

Prepared for

U.S. Army Corps of Engineers
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May 12, 2006



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A Human Health Risk Assessment was performed to evaluate potential risks to human health under current and reasonably foreseeable future conditions for the Elizabeth Mine property (the Site) located in the towns of South Strafford and Thetford, Vermont. The Site is an abandoned copper and iron sulfate (copperas) mine located on Mine Road in the Village of South Strafford within the Town of Strafford, Orange County, Vermont approximately 10 miles west of the Connecticut River Valley. For the purposes of this assessment, the Site includes the Elizabeth Mine property, adjacent properties, and local associated surface waters including the pit lakes, Copperas Brook, Lord Brook, mine drainage tributaries to Lord Brook, the West Branch of the Ompompanoosuc River, and the Ompompanoosuc River.

The risk assessment was performed in accordance with U.S. Environmental Protection Agency (EPA) guidance documents. The EPA develops an estimate of noncarcinogenic effects by the hazard index method. The potential exposure level at the site is divided by a reference level. The reference level (or Reference Dose) represents an exposure level below which health effects are highly unlikely and above which some level of impact could occur. As the hazard index increases above 1, the potential for adverse impact increases. The EPA considers a hazard index above 1 to represent a potentially unacceptable level of risk.

The EPA also develops an estimate of the potential for carcinogenic effects. Potential carcinogenic effects are expressed as a probability or risk of cancer resulting from the exposure. The EPA generally considers a probability of cancer greater than 1 in 10,000 to be the risk level that requires remediation.

The detailed evaluation of human health risks was divided into four major sections: hazard identification, dose-response assessment, exposure assessment, and risk characterization. Risks were evaluated with respect to exposure to chemicals detected in soil, ground water, surface water, sediment, and fish.

The hazard identification section describes the procedures used to identify chemicals of concern. The Site is impacted primarily with metals. The dose-response assessment describes the data relating potential doses received from exposure to chemicals to potential noncarcinogenic or

carcinogenic health effects (response). The exposure assessment presents the estimated level of exposure (i.e., the exposure dose) for each exposure scenario. Table ES-1 summarizes the exposure pathways for this assessment. The following exposure scenarios were considered:

- Adults and children who could live on properties located adjacent to the former Elizabeth Mine property under both current and future conditions;
- Adults and children who could live on the former Elizabeth Mine property (e.g., tailing piles, etc.) under future conditions;
- Adults and children who could swim in surface water bodies on the Site under both current and future conditions;
- Adults and children who could wade in surface water bodies on the Site under both current and future conditions;
- Adults and children who could occasionally eat fish caught locally from the Site under both current and future conditions; and
- Adults and children who could subsist on fish caught locally from the Site under both current and future conditions.

In addition, risks due to exposure to lead for children (the most sensitive receptor) were evaluated using EPA's Integrated Exposure Uptake Biokinetic Model for Lead in Children (IEUBK) model to estimate blood lead concentrations. The model calculates the probability that children's blood lead concentrations will exceed 10 micrograms of lead per deciliter ($\mu\text{g Pb/dl}$). If the probability that children's blood lead concentrations exceeds 10 $\mu\text{g/dl}$ is not greater than 5 percent, the risk is considered acceptable.

The following table summarizes the results of this assessment:

| Exposure Pathway | Non Cancer Risk Below EPA Risk Management Criteria? (HI ≤ 1) | Chemicals above EPA Non-Cancer Risk Management Criteria | Cancer Risk Below EPA Risk Management Criteria (Risk ≤ 1 x 10 ⁻⁴) | Chemicals above EPA Cancer Risk Management Criteria |
|---|--|---|---|---|
| Residential Exposure to Soil | | | | |
| Residential properties | YES | | YES | |
| TP-1 and TP-2 | YES | | YES | |
| TP-3 | YES | | YES | |
| TP-4 | YES | | YES | |
| Artesian Vent (Air Vent) (Underground Workings) | YES | | YES | |
| Sargent Brook | YES | | YES | |
| Copperas Ore Roast Bed, Sargent Brook | YES | | YES | |
| Copperas Factories - Lead Hot Spot | NO | Lead | YES | |
| South Mine and Waste Rock Piles | YES | | YES | |
| South Open Cut | YES | | YES | |
| Furnace Flats North | YES | | YES | |
| Furnace Flats South | YES | | YES | |
| Lord Brook | YES | | YES | |
| Lower Copperas Brook | YES | | YES | |
| West Branch Ompompanoosuc | YES | | YES | |
| Residential Exposure to Ground Water | | | | |
| Residential wells* | NO | Manganese, Cadmium | YES | |
| TP-1 and TP-2 | NO | Manganese, Cadmium, Arsenic, Barium, Nickel, Thallium, Vanadium, Zinc, Lead | NO | Arsenic |
| TP-3 | NO | Manganese, Cadmium, Arsenic, Nickel, Thallium, Vanadium, Zinc, Lead | NO | Arsenic |
| TP-4 | NO | Manganese, Thallium | YES | |
| Lower Copperas Brook | NO | Manganese | YES | |
| Copperas Factories - Lead Hot Spot | NO | Manganese, Cadmium, Zinc | YES | |
| South Open Cut | YES | | YES | |
| South Vent | YES | | YES | |
| Artesian Vent (Underground Workings) | NO | Cadmium, Manganese, Mercury, Zinc | YES | |
| Contact with Surface Water while Swimming | YES | | YES | |
| Contact with Sediment and Surface Water While Wading | YES | | YES | |
| Fishing and Ingestion of Fish (recreational) | YES | | YES | |
| Fishing and Ingestion of Fish (subsistence) | NO | Mercury, Lead | YES | |

*Ingestion of water from former residential wells RES-03 and RES-03A pose an unacceptable risk; risks are within acceptable limits for the other residential wells.

Under current and future conditions, the results from all residential wells except RES-03 and RES-03A indicate the cancer risks and non-cancer risks for residential exposure to groundwater are below EPA risk management criteria. The results also indicate that the hazard indices (i.e., non-cancer risks) and incremental lifetime carcinogenic risks for contact with soil on the residential properties are within acceptable limits.

Under future conditions, the following potential exposures could pose a non-cancer risk above EPA risk management criteria (i.e., hazard index greater than 1) to residents who could live on the former Elizabeth Mine property:

- Ingestion of groundwater within TP-1 and TP-2;
- Ingestion of groundwater within TP-3;
- Ingestion of groundwater within TP-4;
- Ingestion of groundwater within the Lower Copperas Brook Area;
- Ingestion of groundwater within the Artesian Vent (Air Vent) Area (Underground Workings);
- Ingestion of groundwater in the Copperas Brook area near the Lead Hot Spot; and
- Contact with soil in the Lead Hot Spot Area.

In addition, the following potential exposures result in a potential carcinogenic risk above EPA risk management criteria to future residents who could live on the former Elizabeth Mine property:

- Ingestion of groundwater within TP-1 and TP-2; and
- Ingestion of groundwater within TP-3.

Under current or future conditions, contact with surface water or sediment from swimming or wading in surface water bodies located on the Site does not pose an unacceptable risk of noncarcinogenic or carcinogenic effects.

The results also show that contact with surface water or sediment while fishing does not pose an unacceptable risk of noncarcinogenic or carcinogenic risks under current or future conditions. In addition, ingestion of fish from recreational fishing does not pose a significant risk under current or future conditions. Ingestion of fish on a subsistence basis, however, poses a risk above EPA risk management criteria due to mercury and lead under current and future conditions.

In summary, this risk assessment was performed to evaluate current and reasonably foreseeable future risk to human health. This assessment indicates that ingestion of well water from residential wells RES-03 and RES-03A could pose a significant risk to residents using this water as a source of tap water. This assessment also indicates that contact with soil in Copperas Factories – Lead Hot Spot Area poses a significant risk to residents. This assessment also indicates that contact with groundwater within TP-1, TP-2 and the tailing fan below TP-1, TP-3, TP-4, Lower Copperas Brook, the Copperas Factories – Lead Hot Spot Area, and the Artesian Vent (or Underground Workings Area) could pose a risk above EPA risk management criteria to residents if it is used as a source of tap water under future conditions. In addition, ingestion of fish poses a significant risk if fish are ingested on a subsistence basis under current and future conditions. Risks due to swimming, wading, and recreational fishing are all within acceptable limits.

TABLE ES-1
SELECTION OF EXPOSURE PATHWAYS
ELIZABETH MINE

| Scenario Timeframe | Medium | Exposure Medium | Exposure Point | Receptor Population | Receptor Age | Exposure Route | Type of Analysis | Rationale for Selection or Exclusion of Exposure Pathway |
|--------------------|---------------|-----------------|---|------------------------|--------------|---|--|--|
| Current | Groundwater | Groundwater | Tap Water (Private Wells) | Residents | Adult | Ingestion Dermal Contact Inhalation | Quantitative Quantitative Qualitative | Assumes nearby residential wells may be impacted by metals from the Site. Assumes nearby residential wells may be impacted by metals from the Site. Metals are non-volatile, this pathway is negligible. |
| | | | | | Child | Ingestion Dermal Contact Inhalation | Quantitative Quantitative Qualitative | Assumes nearby residential wells may be impacted by metals from the Site. Assumes nearby residential wells may be impacted by metals from the Site. Metals are non-volatile, this pathway is negligible. |
| | Soil | Surface Soil | Lots #1, #2, and #3 | Residents | Adult | Ingestion Dermal Contact Inhalation | Quantitative Quantitative Quantitative | Assumed that residents living adjacent to the Site may be exposed to site impacted soils. Assumed that residents living adjacent to the Site may be exposed to site impacted soils. Assumed that residents living adjacent to the Site may be exposed wind-blown dust from the Site. |
| | | | | | Child | Ingestion Dermal Contact Inhalation | Quantitative Quantitative Quantitative | Assumed that residents living adjacent to the Site may be exposed to site impacted soils. Assumed that residents living adjacent to the Site may be exposed to site impacted soils. Assumed that residents living adjacent to the Site may be exposed wind-blown dust from the Site. |
| | | | | | Adult | Ingestion Dermal Contact | Qualitative Qualitative | Ingestion of sediment is not likely during swimming. Contact with sediment is not likely during swimming. |
| | | | | | Child | Ingestion Dermal Contact | Qualitative Qualitative | Ingestion of sediment is not likely during swimming. Contact with sediment is not likely during swimming. |
| | Sediment | Sediment | Air Vent; South Open Cut; TP-1; TP-2 and tailing fan below TP-1; Lord Brook; Lower Copperas; TP-4; Upper Copperas Brook; Sargent Brook; South Mine and Waste Rock Piles; West Branch Ompompanoosuc; Ompompanoosuc River; and Ompompanoosuc River and Connecticut Confluence | Swimmers | Adult | Ingestion Dermal Contact | Quantitative Qualitative | Ingestion of sediment is likely during wading. Contact with sediment likely to occur during wading. |
| | | | | | Child | Ingestion Dermal Contact | Quantitative Qualitative | Ingestion of sediment is likely during wading. Contact with sediment likely to occur during wading. |
| | | | | Waders | Adult | Ingestion Dermal Contact | Quantitative Quantitative | Ingestion of sediment may occur while fishing. Contact with sediment may occur during fishing. |
| | | | | | Child | Ingestion Dermal Contact | Quantitative Quantitative | Ingestion of sediment may occur while fishing. Contact with sediment may occur during fishing. |
| | | | Lord Brook; West Branch Ompompanoosuc; Ompompanoosuc River; and Ompompanoosuc and Connecticut Confluence | Recreational Fishermen | Adult | Ingestion Dermal Contact | Quantitative Quantitative | Ingestion of sediment may occur while fishing. Contact with sediment may occur during fishing. |
| | | | | | Child | Ingestion Dermal Contact | Quantitative Quantitative | Ingestion of sediment may occur while fishing. Contact with sediment may occur during fishing. |
| | | | Lord Brook; West Branch Ompompanoosuc; Ompompanoosuc River; and Ompompanoosuc and Connecticut Confluence | Subsistence Fishermen | Adult | Ingestion Dermal Contact | Quantitative Quantitative | Ingestion of sediment may occur while fishing. Contact with sediment may occur during fishing. |
| | | | | | Child | Ingestion Dermal Contact | Quantitative Quantitative | Ingestion of sediment may occur while fishing. Contact with sediment may occur during fishing. |
| | Surface Water | Surface Water | Air Vent; South Open Cut; TP-1; TP-2 and tailing fan below TP-1; Lord Brook; Lower Copperas; TP-4; Upper Copperas Brook; Sargent Brook; South Mine and Waste Rock Piles; West Branch Ompompanoosuc; Ompompanoosuc River; and Ompompanoosuc and Connecticut Confluence | Swimmers | Adult | Ingestion Dermal Contact | Quantitative Quantitative | Ingestion of surface water likely during swimming. Contact with surface water occurs during swimming. |
| | | | | | Child | Ingestion Dermal Contact | Quantitative Quantitative | Ingestion of surface water likely during swimming. Contact with surface water occurs during swimming. |
| | | | | Waders | Adult | Dermal Contact | Quantitative | Contact with surface water occurs during wading. |
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| Current | Surface Water | Surface Water | Lord Brook; West Branch Ompompanoosuc; Ompompanoosuc River; and Ompompanoosuc and Connecticut Confluence | Recreational Fishermen | Adult | Dermal Contact | Quantitative | Contact with surface water may occur while fishing. |
| | | | | | Child | Dermal Contact | Quantitative | Contact with surface water may occur while fishing. |
| | | | Lord Brook; West Branch Ompompanoosuc; Ompompanoosuc River; and Ompompanoosuc and Connecticut Confluence | Subsistence Fishermen | Adult | Dermal Contact | Quantitative | Contact with surface water may occur while fishing. |
| | | | | | Child | Dermal Contact | Quantitative | Contact with surface water may occur while fishing. |
| | Biota | Fin Fish Tissue | Lord Brook; West Branch Ompompanoosuc; Ompompanoosuc River; and Ompompanoosuc and Connecticut Confluence | Recreational Fishermen | Adult | Ingestion | Quantitative | Assumes adults fish on the Site for recreational purposes. |
| | | | | | Child | Ingestion | Quantitative | Assumes children fish on the Site for recreational purposes. |
| | | | Lord Brook; West Branch Ompompanoosuc; Ompompanoosuc River; and Ompompanoosuc and Connecticut Confluence | Subsistence Fishermen | Adult | Ingestion | Quantitative | Assumes adults could subsist on locally caught fish. |
| | | | | | Child | Ingestion | Quantitative | Assumes children could subsist on locally caught fish. |
| Future | Groundwater | Groundwater | Tap Water (On-site Monitoring Wells) | Residents | Adult | Ingestion Dermal Contact Inhalation | Quantitative Quantitative Qualitative | Assumes on-site residential wells may be impacted by metals at the Site. Assumes on-site residential wells may be impacted by metals at the Site. Metals are non-volatile, this pathway is negligible. |
| | | | | | Child | Ingestion Dermal Contact Inhalation | Quantitative Quantitative Qualitative | Assumes on-site residential wells may be impacted by metals at the Site. Assumes on-site residential wells may be impacted by metals at the Site. Metals are non-volatile, this pathway is negligible. |
| | Soil | Surface Soil | Air Vent; Sargent Brook; Copperas Ore Roast Bed; Sargent Brook; Copperas Works – Lead Hot Spot; South Mine and Waste Rock Piles; South Open Cut; Furnace Flats North; Furnace Flats South; TP-1; TP-2 and tailing fan below TP-1; TP-3; TP-4; Lord Brook; Lower Copperas Brook; Lots #1, #2, and #3 | Residents | Adult | Ingestion | Quantitative | Assumed that residents living on and adjacent to Site property may be exposed to site impacted soils. |
| | | | | | | Dermal Contact Inhalation | Quantitative Quantitative | Assumed that residents living on and adjacent to Site property may be exposed to site impacted soils. Assumed that residents living on the Site may be exposed wind-blown dust from he Site. |
| | | | | Child | Ingestion | Quantitative | Assumed that residents living on and adjacent to Site property may be exposed to site impacted soils. | |
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| | Sediment | Sediment | Air Vent; South Open Cut; TP-1; TP-2 and tailing fan below TP-1; Lord Brook; Lower Copperas; TP-4; Upper Copperas Brook; Sargent Brook; South Mine and Waste Rock Piles; West Branch Ompompanoosuc; Ompompanoosuc River; and Ompompanoosuc River and Connecticut Confluence | Swimmers | Adult | Ingestion Dermal Contact | Qualitative Qualitative | Ingestion of sediment is not likely during swimming. Contact with sediment is not likely during swimming. |
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| Future | Sediment | Sediment | Air Vent; South Open Cut; TP-1; TP-2 and tailing fan below TP-1; Lord Brook; Lower Copperas; TP-4; Upper Copperas Brook; Sargent Brook; South Mine and Waste Rock Piles; West Branch Ompompanoosuc; Ompompanoosuc River; and Ompompanoosuc River and Connecticut Confluence | Waders | Adult | Ingestion Dermal Contact | Quantitative Quantitative | Ingestion of sediment is likely during wading. Contact with sediment is likely to occur while wading. |
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| | Surface Water | Surface Water | Air Vent; South Open Cut; TP-1; TP-2 and tailing fan below TP-1; Lord Brook; Lower Copperas; TP-4; Upper Copperas Brook; Sargent Brook; South Mine and Waste Rock Piles; West Branch Ompompanoosuc; Ompompanoosuc River; and Ompompanoosuc and Connecticut Confluence | Swimmers | Adult | Ingestion Dermal Contact | Quantitative Quantitative | Ingestion of surface water likely during swimming. Contact with surface water occurs during swimming. |
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|-----------------------|--------|--------------------|--|------------------------|-----------------|-------------------|---------------------|---|
| Future | Biota | Fin Fish Tissue | Lord Brook; West Branch Ompompanoosuc; Ompompanoosuc River; and Ompompanoosuc and Connecticut Confluence | Subsistence Fishermen | Adult | Ingestion | Quantitative | Assumes adults could subsist on locally caught fish. |
| | | | | | Child | Ingestion | Quantitative | Assumes children could subsist on locally caught fish. |